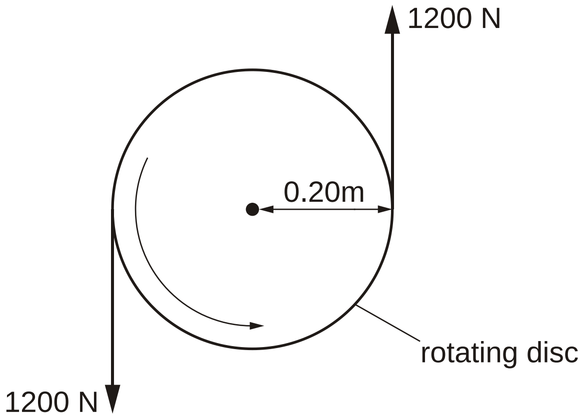
Questions on Work & Energy

1. Describe one example where elastic potential energy is stored.

....

[Total 1 mark]

2. The figure below shows two forces, each of magnitude 1200 N, acting on the edge of a disc of radius 0.20 m.



(a) (i) Define the *torque of a couple.*

....

....

[1]

(ii) Calculate the torque produced by these forces.

torque = ...N m

[2]

(b) This torque is needed to overcome friction and keep the disc rotating at a constant rate.

(i) Show that the work done by the **two** forces when the disc rotates one complete revolution is about 3000 J.

[2]

(ii) Calculate the power required to keep the disc rotating at 40 revolutions per second.

power = ... W

[2]

[Total 7 marks]

3. Fig. 1 shows part of the force-extension graph for a spring. The spring obeys Hooke's law for forces up to 5.0 N.

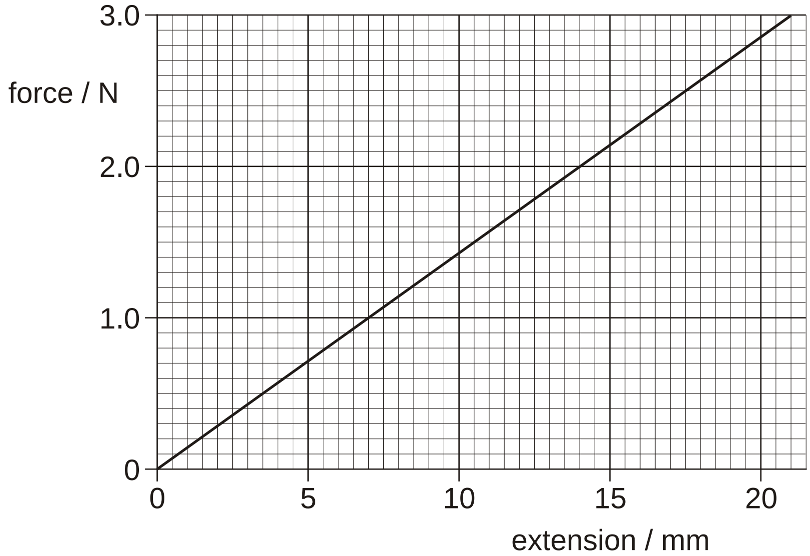


Fig. 1

(a) Calculate the extension produced by a force of 5.0 N.

extension = ... mm

[2]

(b) Fig. 2 shows a second identical spring that has been put in parallel with the first spring. A force of 5.0 N is applied to this combination of springs.

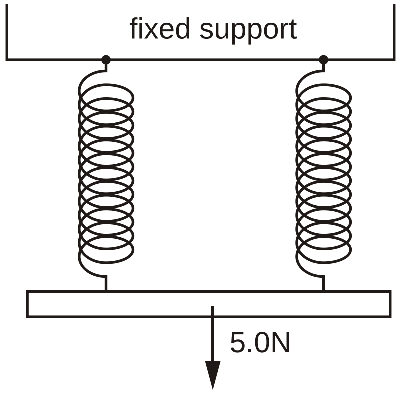


Fig. 2

For the arrangement shown in Fig. 2, calculate

(i) the extension of each spring

extension = ... mm

[2]

(ii) the total strain energy stored in the springs.

strain energy = ... J

[2]

(c) The Young modulus of the wire used in the springs is 2.0×10^{11} Pa. Each spring is made from a straight wire of length 0.40 m and cross-sectional area 2.0×10^{-7} m^2. Calculate the extension produced when a force of 5.0 N is applied to this straight wire.

extension = ...m

[3]

(d) Describe and explain, without further calculations, the difference in the strain energies stored in the straight wire and in the spring when a 5.0 N force is applied to each.

....

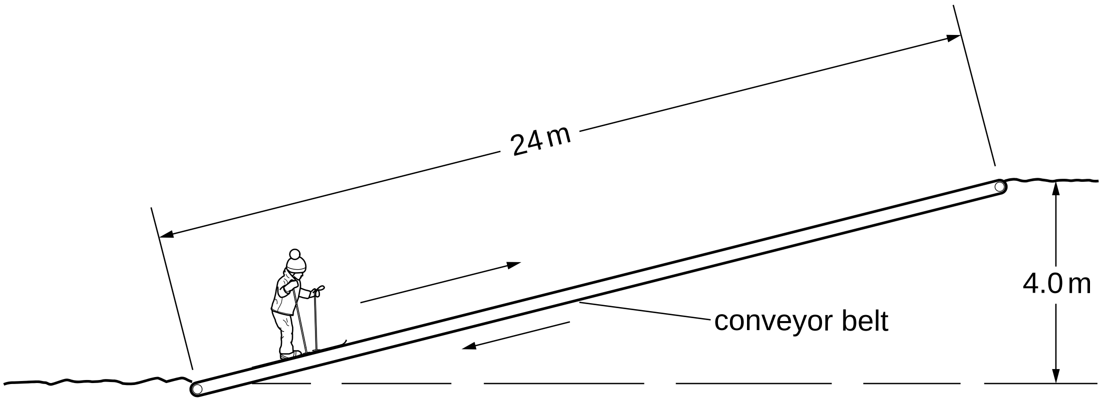
....

....

[2]

[Total 11 marks]

4. The figure below illustrates a conveyor belt for transporting young children up a snow-covered bank so that they can ski back down.



A child of mass 20 kg travels up the conveyor belt at a constant speed. The distance travelled up the slope is 24 m and the time taken is 55 s. The vertical height climbed in this time is 4.0 m.

(a) For the child on the conveyor belt, calculate

(i) her speed

speed = ... m s^{-1}

[2]

(ii) her kinetic energy

kinetic energy = ... J

[2]

(iii) the increase in her potential energy for the complete journey up the slope.

potential energy = ... J

[2]

(b) (i) The conveyor belt is designed to take a maximum of 15 children at any one time. Calculate the power needed to lift 15 children of average mass 20 kg through a height of 4.0 m in 55 s.

power = ... W

[2]

(ii) The belt is driven by an electric motor. State **two** reasons why the motor needs a greater output power than that calculated in **(b)(i)**.

....

....

....

....

[2]

[Total 10 marks]

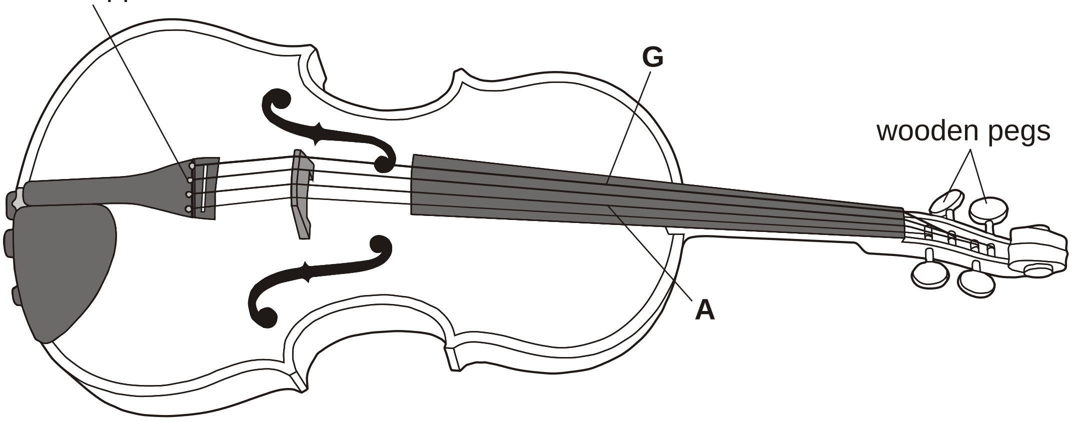
5. State the principle of conservation of energy.

....

....

[Total 1 mark]

6. The figure below shows a violin.



Two of the wires used on the violin, labelled **A** and **G** are made of steel. The two wires are both 500 mm long between the pegs and support. The 500 mm length of wire labelled **G** has a mass of 2.0×10^{-3} kg. The density of steel is 7.8×10^{3} kg m^{-3}.

(i) Show that the cross-sectional area of wire **G** is 5.1×10^{-7} m^2.

[2]

(ii) The wires are put under tension by turning the wooden pegs shown in the figure. The Young modulus of steel is 2.0×10^{11} Pa.
Calculate the tension required in wire **G** to produce an extension of 4.0×10^{-4} m.

tension = ...N

[3]

(iii) Wire **A** has a diameter that is half that of wire **G**. Determine the tension required for wire **A** to produce an extension of 16×10^{-4} m.

tension = ...N

[1]

(iv) State the law that has been assumed in the calculations in **(ii)** and **(iii)**.

....

[1]

[Total 7 marks]

7. The results given in the table below are obtained in an experiment to determine the Young modulus of a metal in the form of a wire. The wire is loaded in steps of 5.0 N up to 25.0 N and then unloaded.

	loading	unloading
load / N	extension / mm	extension /mm
0.0	0.00	0.00
5.0	0.24	0.24
10.0	0.47	0.48
15.0	0.71	0.71
20.0	0.96	0.95
25.0	1.20	1.20

(i) Using the results in the table and without plotting a graph, state and explain whether the deformation of the wire

1 is plastic or elastic

....

....

....

[1]

2 obeys Hooke's law.

....

....

....

[2]

(ii) Explain how the extension and length of the wire may be determined experimentally.

....

....

....

....

[2]

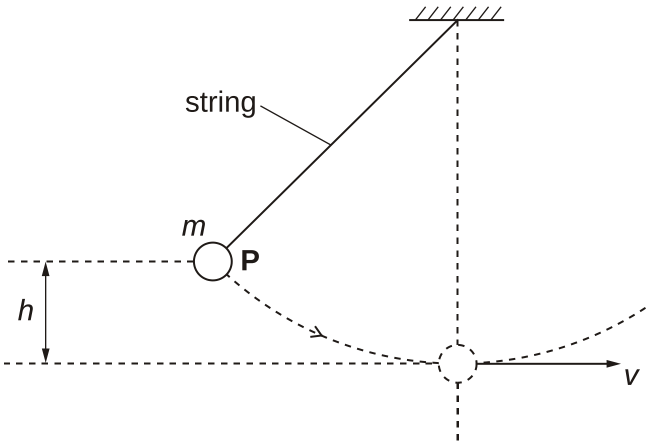
(iii) The wire tested is 1.72 m long and has a cross-sectional area of 1.80×10^{-7} m^2. Use the extension value given in the table for a load of 25.0 N to calculate the Young modulus of the metal of the wire.

Young modulus = ... Pa

[3]

[Total 8 marks]

8. The figure below shows a simple pendulum with a metal ball attached to the end of a string.



When the ball is released from **P**, it describes a circular path. The ball has a maximum speed *v* at the bottom of its swing. The vertical distance between **P** and bottom of the swing is *h*. The mass of the ball is *m*.

(i) Write the equations for the change in gravitational potential energy, E_p, of the ball as it drops through the height *h* and for the kinetic energy, E_k, of the ball at the bottom of its swing when travelling at speed *v*.

E_p =

E_k =

[1]

(ii) Use the principle of conservation of energy to derive an equation for the speed *v*. Assume that there are no energy losses due to air resistance.

[2]

[Total 3 marks]

9. Some countries in the world have frequent thunderstorms. A group of scientists plan to use the energy from the falling rain to generate electricity. A typical thunderstorm deposits rain to a depth of 1.2×10^{-2} m over a surface area of 2.0×10^{7} m^2 during a time of 900 s. The rain falls from an average height of 2.5×10^{3} m. The density of rainwater is 1.0×10^{3} kg m^{-3}. About 30% of the gravitational potential energy of the rain can be converted into electrical energy at the ground.

(i) Show that the total mass of water deposited in 900 s is 2.4×10^{8} kg.

[2]

(ii) Hence show that the average electrical power available from this thunderstorm is about 2 GW.

[3]

(iii) Suggest one problem with this scheme of energy production.

....

....

[1]

[Total 6 marks]

10. The force against length graph for a spring is shown in Fig. 1.

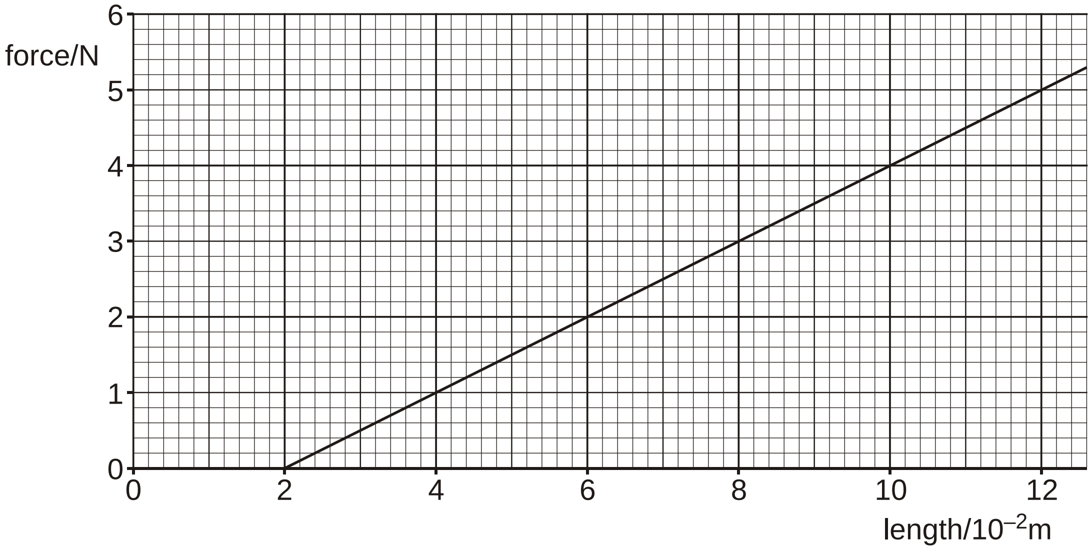


Fig. 1

(a) Explain why the graph does not pass through the origin.

....

.... [1]

(b) State what feature of the graph shows that the spring obeys Hooke's law.

....

.... [1]

(c) The gradient of the graph is equal to the force constant *k* of the spring. Determine the force constant of the spring.

force constant = ... N m^{-1}

[2]

(d) Calculate the work done on the spring when its length is increased from 2.0×10^{-2} m to 8.0×10^{-2} m.

work done = ... J

[2]

(e) One end of the spring is fixed and a mass is hung vertically from the other end. The mass is pulled down and then released. The mass oscillates up and down. Fig. 2 shows the displacement *s* against time *t* graph for the mass.

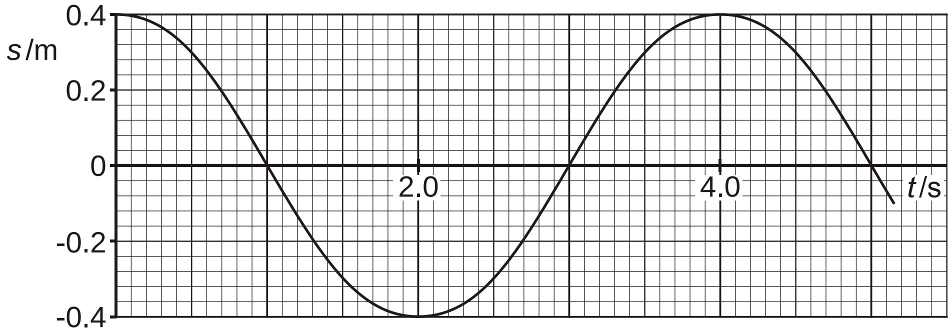


Fig. 2

Explain how you can use Fig. 2 to determine the **maximum** speed of the mass. You are not expected to do the calculations.

....

....

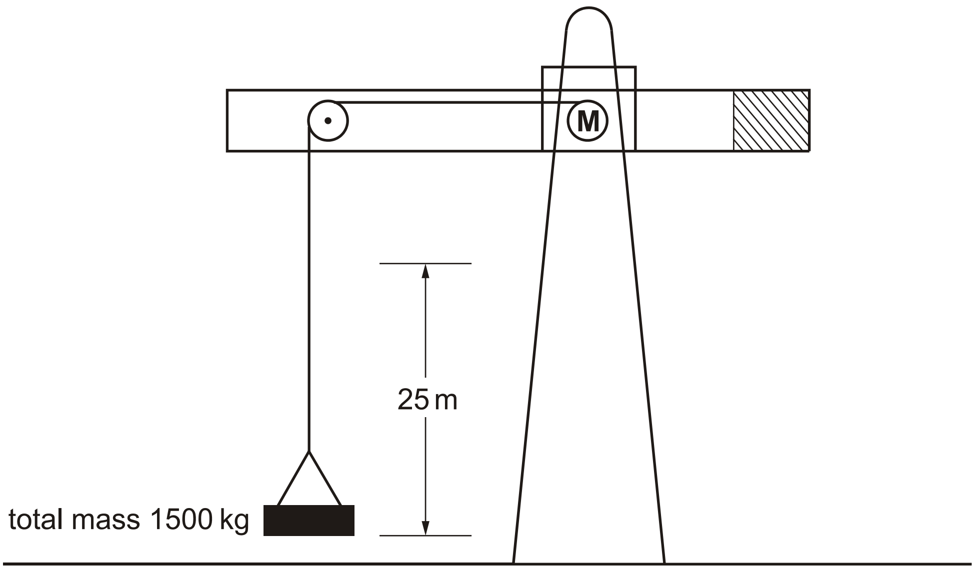
....

....

[2]

[Total 8 marks]

11. The figure below shows a crane that is used to move heavy objects.



The motor **M** in the crane lifts a total mass of 1500 kg through a height of 25 m at a constant velocity of 1.6 m s^{-1}.

Calculate

(i) the tension in the lifting cable

tension = ... N

[2]

(ii) the time taken for the mass to be raised through the height of 25 m

time = ... s

[1]

(iii) the rate of gain of potential energy of the mass

rate of gain of potential energy = ... J s^{-1}

[3]

(iv) the minimum output power of the motor used to raise the mass.

power = ... W

[1]

[Total 7 marks]

12. (a) Define *the Young modulus* of a material.

....

....

[1]

(b) Explain why the quantity strain has no units.

....

....

[1]

[Total 2 marks]